

# A PRELIMINARY CONCEPTUALIZATION OF SHARED MENTAL MODELS IN A PROJECT TEAM DOMAIN

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Project teams are routinely used in today's workplace. These teams are typically composed of members representing a variety of different functional units (Cohen & Bailey, 1997). The use of project teams allows organizations to tap the specialized, unique knowledge of these team members concurrently. Teams are able to improve performance when completing complex assignments by utilizing the expertise of each team member to the advantage of the team. While this idea sounds appealing, the implementation is not easy. The functional perspectives of team members are internalized. Even when told to act in the team's best interest, these team members are biased toward the interests of their function (Dearborn & Simon, 1958). The team leader's challenge is to shift the team members' biases from their function to the team.

Katzenbach and Smith (1999) have found that successful teams put significant effort into developing an agreed upon approach for conducting the requisite work. In spite of this finding, traditional models of teams and recent work in the field often have ignored the cognitive processes that constitute successful teamwork (Lembke & Wilson, 1998), where teamwork refers to the multitude of processes required to maintain the team such as cooperation, communication, and interpersonal relationships (McIntyre & Salas, 1995). Through the initial stages of development, team members must consider aspects of teamwork that include their fellow team members' potential contributions, the assignment they have been given, and the level of interaction required, which are inherently cognitive processes. Further, the team must achieve cognitive unification regarding the aspects of teamwork unique to their circumstance. Shared mental models (SMM) are useful in assessing how well a team achieves this cognitive unification (Salas, Dickinson, Converse, & Tannenbaum, 1992).

In this paper, we present our theoretically based preliminary conceptualization of SMM. The creation of such a framework, including the establishment of a set of measurable constructs that represent cognitive requirements of teamwork, is necessary to guide research in this area. Further, an understanding of these requirements will aid in establishing guidelines for teams.

## Mental Models and Shared Mental Models

Humans create representations of their worlds, called mental models, which are simpler than the entities they represent (Johnson-Laird, 1983). The content of mental models includes specific types of knowledge humans use to describe, explain, and predict their surroundings (Rouse & Morris, 1986). The acts of describing, explaining, and predicting are accomplished through a heuristic function that classifies and retrieves the most salient pieces of information about situations, objects, and environments (Cannon-Bowers, Salas, & Converse, 1993). The purpose of mental models is to aid in the reduction of uncertainty by allowing individuals to screen information until only relevant pieces are retrieved (Klimoski and Mohammed, 1994).

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Additionally, by utilizing information that is categorically sorted and stored within their minds, humans can “run” many possible scenarios for a complex situation to ascertain various potential outcomes, in a manner similar to that of a computer simulation (Cannon-Bowers et al., 1993). This process of identifying potential outcomes further reduces uncertainty. Formally, shared mental models are “knowledge structures held by members of a team that enable them to form accurate explanations and expectations for the task, and in turn, to coordinate their actions and adapt their behavior to demands of the task and other team members” (Cannon-Bowers et al., 1993, p. 228).

A collection of individuals working together as a team also need mental representations in order to effectively accomplish their assigned work. These mental representations are not held collectively at the group level, rather they are held at the individual level. At the onset of team activity, many team members may share common representations based on their experiences that have been common or shared (Bar-Tal, 1990). As the team begins to interact and move through the phases of team development, the individual mental models evolve as the team undergoes a complex, iterative process (Donnellon, Gray, & Bougon, 1986) until they converge to a point that allows the team to function as a collective. Eden and his associates have observed this type of convergence through the use of causal maps (e.g., Eden, 1992; Eden, Ackermann, & Cropper, 1992). Other researchers have observed this convergence through the articulation and refinement of the language and structure used by team members (e.g., Cannon-Bowers et al., 1993; Hill & Levenhagen, 1995).

The nature of the information that must be shared among team members is not well established in the literature. Researchers argue that the information contained in SMM may be in the form of mental representations that help individuals interpret the circumstances in which they find themselves or it may be in the form of behavioral routines to aid in decision making (Klimoski & Mohammed, 1994). Further complicating the issue, evidence has shown that individuals need to develop multiple models representing aspects of the team environment about which team members must be cognitively unified (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000).

### **Shared Mental Models Preliminary Conceptualization**

Conceptualizations are typically domain-specific due to the unique requirements of various domains (Rouse & Morris, 1986), therefore, we developed a conceptualization for project teams. Project teams, as opposed to work teams, parallel teams, or management teams, are unique in that their assignments are time-limited and non-repetitive (Cohen & Bailey, 1997). This uniqueness constitutes their domain and dictates that the contents of their SMM will differ from the other types of teams.

The preliminary conceptualization we developed, seen in Figure 1, is a two-dimensional framework based on the need for multiple SMM and the information processing requirements necessary to reconcile differences among team members. The first task in developing the proposed conceptualization was to identify the important aspects of the project team domain that require a SMM. As can be seen in Figure 1, we begin with three models based on the work of Cannon-Bowers et al. (1993): team membership, the assigned project, and the mode of team interaction. Additionally, we are exploring other mental models that may be necessary in a project team domain, including the organizational climate as it relates to the use of and reward for teamwork and the organizational context in which the project was conceived.

	Team Membership	Project	Team Interaction
Differentiation	Functional Diversity	Nature of the Project	Interdependence
Integration	Membership Adequacy	Project Goals	Team Processes

Figure 1. Preliminary conceptualization of project team shared mental models

The second dimension of our SMM conceptualization is integrative complexity at the team level. As previously stated, mental models are knowledge structures individuals use to describe, explain, and predict system behavior (Rouse & Morris, 1986). Accurate descriptions and explanations allow team members to manipulate their models for the prediction of future events. Given this fact, the cognitive properties necessary for describing and explaining must be incorporated into the conceptualization. In the field of integrative complexity, researchers deal with the information processing capabilities of individuals, specifically, how individuals differentiate available alternatives and subsequently reconcile, or integrate, similarities and differences among the alternatives to determine a course of action (Driver & Streufert, 1969). Gruenfeld and Hollingshead (1993) extended this idea to the group level when they demonstrated that the concept of collective cognition could occur. In sum, our conceptualization operationalizes the team members' abilities to appreciate the differences that exist within their team context, while concurrently recognizing the conceptual connections among these differences in order to work together in a manner amenable to all involved. Moreover, by incorporating the dimensions of differentiation and integration into the conceptualization of SMM, agreement among team members will demonstrate a team's ability to process information as a collective.

For each dimension, individual level data will be collected, based on the premise that individuals hold mental models and as interaction occurs these individual mental models begin to converge to create SMM. As such, the level of agreement among individuals determines the level of sharing that is occurring among team members. The conceptual framework in Figure 1 also includes our recommendations for how the dimensions can be measured. Beginning with the team membership mental model, a team member, relying on their transactive memory (Wegner, 1987), would attempt to identify the functional diversity of the membership and then indicate if this level of diversity integrates into a membership capable of completing the requisite taskwork. The project mental model requires team members be able to describe the nature of the project and how well the various aspects of the projects have been integrated into a set of project goals. Finally, the team interaction mental model asks team members to describe the level of interdependence dictated by the assigned project representing the level of interaction required (Kiggundu, 1981) and then to state how well the team is functioning as a collective, given this requisite interdependence.

## Conclusions

The conceptualization we present in this paper integrates the various mental models and the information processing requirements necessary in a project team domain. Finalizing, operationalizing, and testing the conceptualization will contribute to a better understanding of the cognitive requirements of project team members. At that time, the impact of shared mental models on project team performance can be ascertained. From a practitioner's perspective, an understanding of the mental models in use will provide guidance for team development. While the framework presented represents a preliminary look at the dimensions required in a project team domain, the two-dimensional conceptualization could be generalized to any type of team by determining the appropriate domain-specific dimensions.

## References

- Bar-Tal, D. 1990. *Group beliefs: a conception for analyzing group structure, processes, and behavior*. New York: Springer-Verlag.
- Cannon-Bowers, J. A., Salas, E., & Converse, S. A. 1993. Shared mental models in expert team decision making. In N. J. Castellan, Jr. (Ed.), *Individual and group decision making: current issues*: 221-246. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.
- Cohen, S. G. & Bailey, D. E. 1997. What makes teams work: Group effectiveness research from the shop floor to the executive suite. *Journal of Management*, 23 (3): 239-290.
- Dearborn, D. C. & Simon, H. A. 1958. Selective perception: a note on the departmental identifications of executives. *Sociometry*, 21 (2): 140-144.
- Donnellon, A., Gray, B., & Bougon, M. 1986. Communication, meaning, and organized action. *Administrative Science Quarterly*, 31 (43-55).
- Driver, M. J. & Streufert, S. 1969. Integrative complexity: an approach to individuals and groups as information-processing systems. *Administrative Science Quarterly*, 14 (272-285).
- Eden, C. 1992. On the nature of cognitive maps. *Journal of Management Studies*, 29 (3): 261-265.
- Eden, C., Ackermann, F., & Cropper, S. 1992. The analysis of cause maps. *Journal of Management Studies*, 29 (3): 309-324.
- Gruenfeld, D. H. & Hollingshead, A. B. 1993. Sociocognition in work groups: the evolution of group integrative complexity and its relation to task performance. *Small Group Research*, 24 (3): 383-405.
- Hill, R. C. & Levenhagen, M. 1995. Metaphors and mental models: sensemaking and sensegiving in innovative and entrepreneurial activities. *Journal of Management*, 21 (6): 1057.
- Johnson-Laird, P. N. 1983. *Mental models: towards a cognitive science of language, inference, and consciousness*. Cambridge, MA: Harvard University Press.
- Katzenbach, J. R. & Smith, D. K. 1999. The discipline of teams. *Harvard Business Review*, 71 (2): 111-120.
- Kiggundu, M. N. 1981. Task interdependence and the theory of job design. *Academy of Management Review*, 6 (3): 499-508.
- Klimoski, R. & Mohammed, S. 1994. Team mental model: Construct or metaphor? *Journal of Management*, 20 (2): 403-437.
- Lembke, S. & Wilson, M. G. 1998. Putting the "team" into teamwork: alternative theoretical contributions for contemporary management practice. *Human Relations*, 51 (7): 927.
- Mathieu, J. E., Heffner, T. S., Goodwin, G. F., Salas, E., & Cannon-Bowers, J. A. 2000. The influence of shared mental models on team process and performance. *Journal of Applied Psychology*, 85 (2): 273-283.
- McIntyre, R. M. & Salas, E. 1995. Measuring and managing for team performance: Emerging principles from complex environments. In R. A. Guzzo, E. Salas, & associates (Eds.), *Team effectiveness and decision making in organizations*: 9-45. San Francisco, CA: Jossey-Bass Publishers.
- Rouse, W. B. & Morris, N. M. 1986. On looking into the black box: Prospects and limits in the search for mental models. *Psychological Bulletin*, 100 (3): 349-363.
- Salas, E., Dickinson, T. D., Converse, S. A., & Tannenbaum, S. I. 1992. Toward an understanding of team performance and training. In R. W. Swezey & E. Salas (Eds.), *Teams: Their training and performance*: 3-30. Norwood, NJ: Ablex Publishing Corporation.
- Wegner, D. M. 1987. Transactive memory: A contemporary analysis of the group mind. In B. Mullen & G. R. Goethals (Eds.), *Theories of group behavior*: 185-208. New York: Springer-Verlag.

# Preliminary Conceptualization of Shared Mental Models in a Project Team Domain

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# Overview

- ❖ Definitions
- ❖ Background
- ❖ Preliminary Conceptualization
- ❖ Contributions
- ❖ Future Directions



# Cross-Functional Project Teams

A collection of two or more individuals, representing different functional areas, assembled to work on a time-limited, non-repetitive assignment.

Source: Cohen and Bailey, 1997



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# Taskwork vs. Teamwork

- ❖ Taskwork

The functional job behaviors required to accomplish the assigned task.

- ❖ Teamwork

The multitude of processes required to maintain the team such as cooperation, communication, interpersonal relationships.

Source: McIntyre and Salas, 1995



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# Shared Mental Models by Any Other Name . . .

- ❖ Cause maps
- ❖ Collective mind
- ❖ Schemas
- ❖ Shared cognition
- ❖ Sociocognition
- ❖ Team knowledge



# Background

- ❖ Mental models are
  - used to describe, explain, and predict surroundings (Rouse and Morris, 1986) . . .
  - . . . thereby aiding in the reduction of uncertainty (Klimoski and Mohammed, 1994) . . .
  - . . . by “running” possible scenarios, using the most salient pieces of information, to ascertain potential outcomes (Cannon-Bowers, Salas, and Converse, 1993).
- ❖ Shared Mental Models are cognitively unified individual-level mental models held by team members.



# Shared Mental Models Defined

- ❖ Shared Mental Models
  - ◆ “Knowledge structures held by members of a team that enable them to form accurate explanations and expectations for the task, and in turn, to coordinate their actions and adapt their behavior to demands of the task and other team members” (Cannon-Bowers, Salas, & Converse, 1993, p. 228).
- ❖ Schemas
  - ◆ “Built-up repertoires of tacit knowledge that are used to impose structure upon, and impart meaning to, otherwise ambiguous social and situational information to facilitate understanding” (Gioia, 1986, p. 56).
- ❖ Interpretive schemes
  - ◆ “. . . shared, fundamental (though often implicit) assumptions about why events happen as they do and how people are to act in different situations” (Bartunek, 1984, p. 355).



# Shared Mental Models

Mental representations  
based on  
past experiences and inherent knowledge  
that  
aid individuals in determining the best  
course of future action.



# Expected Outcomes

- ❖ Better task performance (e.g., Entin and Serfaty, 1999; Walsh, Henderson, and Deighton, 1988)
- ❖ Better team processes that lead to better task performance (e.g., Ensley and Pearce, 2001; Mathieu, Heffner, Goodwin, Salas, and Cannon-Bowers, 2000)
- ❖ Better motivational outcomes



# Current Limitations in the Field

- ❖ No consensus regarding:
  - ◆ Identification of what should be shared
  - ◆ Definition of shared
  - ◆ Measurement of shared mental models
  - ◆ Effects of shared mental models on team outcomes

Source: Cannon-Bowers and Salas, 2001



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# Preliminary Conceptualization

- ❖ Two dimensional framework
  - ◆ Shared mental models' contents
  - ◆ Information processing phases



# Shared Mental Models' Contents

- ❖ Multiple models have been identified (e.g., Mathieu, Heffner, Goodwin, Salas, and Cannon-Bowers, 2000)
- ❖ Determinants of shared mental models (e.g., Kraiger and Wenzel, 1997)



# Shared Mental Models' Contents

## Determinants

- ❖ Individual
- ❖ Team
- ❖ Organization
- ❖ Environment

## Models

- ❖ Team Membership
- ❖ Project (taskwork)
- ❖ Interaction (teamwork)
- ❖ Climate
- ❖ Context



# Preliminary Conceptualization

- ❖ Two dimensional framework
  - ◆ Shared mental models content
  - ◆ Information processing phases



# Information Processing

- ❖ Individual level (e.g., Shroeder, Driver, and Streufert, 1967)
- ❖ Group level (e.g., Gruenfeld and Hollingshead, 1993; Hinsz, Tindale, and Vollrath, 1997)



# Information Processing

- ❖ Differentiation

- ❖ Integration



# Preliminary Conceptualization

	Team Members	Project	Team Interaction	Climate	Context
Differentiation					
Integration					



# Information Processing

- ❖ Differentiation

The identification of multiple perspectives

- ❖ Integration



# Differentiation As a Transactive Memory System

- ❖ Transactional memory is a cooperative memory system for encoding, storing, and retrieving information (Wegner, 1987, 1995).
- ❖ Transactional memory research has typically examined information about expertise.
- ❖ Each shared mental model will require its own transactional memory directory.



# Information Processing

- ❖ Differentiation

The identification of multiple perspectives

- ❖ Integration

The reconciliation of the various perspectives into functioning mental representations



# Integration

- ❖ High levels of integration can limit the scope of the information considered by a team (e.g., Corner, Kinicki, and Keats, 1994)
- ❖ Integration levels
  - ◆ are dependent upon shared mental model content
  - ◆ determine the requisite sharing level



# Sharing

- ❖ To have in common
- ❖ To divide

Sources: Cooke, Salas, Cannon-Bowers, and Stout, 2000; Klimoski and Mohammed, 1994; Mohammed and Dunnville, 2001



# Integration and Sharing

# Low Integration



## *To have in common:*



# Compatible

## Overlapping

# Identical

## *To divide:*



# Single Individual

# Equitably Distributed



# Shared Mental Models' Corresponding Sharing Levels

<u>Models</u>	<u>Sharing Level</u>
❖ Team Membership	❖ Compatible
❖ Project (goals)	❖ Identical
❖ Project (work content)	❖ Distributed
❖ Interaction	❖ Overlapping
❖ Climate	❖ Overlapping
❖ Context	❖ Overlapping



# Preliminary Conceptualization

## Sample Operationalizations

	Team Membership	Project	Team Interaction
Differentiation	Functional Diversity	Nature of the Project	Interdependence
Integration	Membership Adequacy	Project Goals	Team Processes



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# Contributions

- ❖ Practitioners
  - ◆ Guidance for team development
- ❖ Academicians
  - ◆ Framework for use in future empirical work



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# Future Directions

- ❖ Conceptualization Finalization and Field Validation
- ❖ Measurement Instrument Development and Validation
- ❖ Application Development
  - ◆ Exercises for Virtual Teams
  - ◆ Diagnostic Tools for Teams
  - ◆ Tests of Impact on Team Performance

